Extended Abstract

Conceiving and making the material and operational 'apparatus' that is needed for constructing architectural artefacts, is usually not associated with the architect's tasks, but rather with the tasks of those in charge of the practical execution of the work on and around a building site. But in a series of 'design by making' workshops, in which students engage in design and construction at scale one on one, with one type of material, and projects are developed from the material itself, and from within the physical actions of manipulating and transforming it, this apparatus sometimes emerges by necessity. Since the overall aim of these workshops, held together by the common denominator 'Tectonics/Structures in Building Culture', is to learn architecture from within practices of making, developing an understanding of what is at stake whilst engaged within these practices is a pressing issue. Paying attention exclusively to the architectural end result, the built artefact, as is often the default mode in the discourses surrounding architecture, is not a sustainable option.

The activities or doings, the experiences and all the material results that are produced during those processes of making are to be incorporated too, if one is to understand the complex patterns of learning experiences that is associated with building architectural situations at 'real life' scale. It is important to recognise that it is not simply the architectural objects that are 'real life', but the events that lead to it as well, including the 'real life' experiences that stem from being incorporated within them, and the whole relational set-up needed to keep them running.

The notion of 'apparatus' refers to a 'construction of means', in the sense of a setting-up of a complex of resources, i.e. the things collectively necessary for the performance of some activity and the equipment used in doing it, as well as the activation and directing of those resources during a process of making. That is what the title of this text, 'Constructing things for Constructing other Things' refers to, namely, the careful elaboration and making operative of the means needed for reaching the ends that we have set ourselves. Apparatus encompasses "the means

Tools, Techniques and Apparatus

_ This text is one of a set of texts by different authors, engaging with issues that emerged within the environment of 'design by making' workshops with students in architecture. They all investigate specific aspects of building at full scale as an educational tool for teaching and learning architecture. The overall aim of the workshops, held together by the common denominator 'Tectonics/Structures in Building Culture', is to learn architecture from within practices of making, in which one engages in design and construction at scale one on one, with one type of material. The architectural projects have to be developed from the material itself and from the direct physical engagements with it, or in other words, from the actions of manipulation and transformation of the material itself and not from pre-determined ideation. The technical operations of shaping, cutting, assembling, arranging, joining and so forth, are required to be more than instrumental, given that they have to be explorative and designerly actions too. Therefore, the construction process duly has to become a design process, one that is not remote from the execution of the work, but is integral to it.

The purpose of this specific text is to highlight the role played, within this endeavour, by *'the means whereby a specific production is made existent or a task accomplished' (Wiktionary, accessed on 14dec2015)*, or in one word, the *'apparatus'*. The etymology of the term indicates that it embodies both an orientation towards an end, as well as a preparation or a making ready for that end. More precisely, and applied to our context, one can say that the notion of 'apparatus' refers to a 'construction of means', in the sense of a setting-up of a complex of resources, i.e. *'the things collectively necessary for the performance of some activity and the equipment used in doing it'*, as well as the activation and directing of those resources. That is what the title of this text, 'Constructing things for Constructing other Things', explicitly refers to, namely, the careful elaboration and making operative of the means needed for reaching the ends that we have set ourselves. The tools and the techniques used for bringing the whole set-up into operation are intricate to the notion of apparatus. Within the lines that follow I will develop my argument starting from tools and I will move gradually towards the more comprehensive theme of apparatus. For this purpose I will use some examples of how it unfolded within the activities of learning Architecture by making it in full scale.

The apparatus incorporates a process of becoming along with the procedures and operational sequences that compose and define that process. Creating an apparatus induces a reflection upon this process and the different roles the apparatus has to play. It needs to embody a capacity to mediate between material and manipulation, between process and

whereby a specific production is made existent or a task accomplished" (Wiktionary, accessed on 14dec2015) and consequently, the tools we use, their capacities and the techniques by which the whole set-up is brought into action, are intricate to it.

Our experience from the various 'design by making' workshops demonstrates that conceiving and making an apparatus and its assortment of tools and techniques, either partially or completely, is pedagogically relevant and necessarily creative, besides being useful and practical. The apparatus and the tools incorporate a process of becoming along with the procedures and operational sequences that compose and define that process. Creating them induces a reflection upon this process and the different roles apparatus and tools have to play. They need to posses a similar intelligence, so to speak, as the artefact that is made with them. Moreover, they can be as fascinating and beautiful because of their inherent capacity to mediate between material and manipulation, between process and result, between movement and statics and between idea and action in making. They determine the thing that is made with it, but conversely their character and capacities are themselves determined by that very thing, at least when they are created from the qualities they have to anticipate upon.

What is more, engaging with apparatus and tools, with their conception and their making, can also be seen as an architectural project, one that is nested within another, but with comparable demands and characteristics, dealt with from a projective stance and directed towards creating a new and better relational situation between us and our environment. Means and ends have to be reconfigured, meaning that the apparatus/tool which is supposed to be a means in the first place, will be an end in itself before that, one that has to be brought into existence first. It is only when it exists that the larger process in which it is nested, that of making the actual or principal end, can proceed in due course. For this to happen, the apparatus/tool must be brought into use, and it is this use that makes it complete by exposing it to the concrete relational situations embedded in making activities. By being part of a context of use it transforms from a project into an actor with whom one has to engage physically, and that influences both the dynamics of the practice and the outcome that results from the practice.

result, between movement and statics and between idea and action in making. The dialectical relations incorporated within apparatus (between set-up, techniques and tools) determine the thing that is made with it, but conversely its character is itself determined by that very thing, at least when it is created from the qualities it anticipates upon.

In a context of learning architecture from within a building practice, making a good, useful, practical and effective apparatus is an act of creativity and imagination that deserves to be valued at a similar level of importance as the actual architectural artefact. It may be that it is simply a technical instrument of which we expect no more than that it helps to construct something else, but in saying that we veil that it is part of the "interface between the object (material or artefact or organism) and an environment which, in the case of the artefact, critically includes its maker" (Ingold 2000/2011, p.345) and obscure it's capacity to transform. We tend to be oblivious to this cover-up, notwithstanding the fact that understanding the role of apparatus and tools appears to be crucial for us to truly comprehend physical and material processes, for ensuring high quality work, for providing ease and comfort in doing the construction work itself, and finally, but not in the least, for being able to work harmoniously and reach qualitative results together with others. The extended paper makes a start with engaging some of the issues that are at stake in the construction of means and reflects on a more comprehensive role of apparatus, tools and techniques when learning architecture by making constructions, and in it's wake *'become builders by building'* (Aristotle, 1953/2004, p.32).

References

Aristotle, 1953/2004, The Nicomachean Ethics, London, Penguin Books.
Ingold, Tim 2000/2011, The Perception of the Environment, Essays on Livelihood, Dwelling and Skill, London and New York, Routledge

Means and Ends

_ For all workshops the unambiguously stated end, presented to and required of the students, is the construction of architectural artefacts at full scale or in other words, built works. But since the underlying goal is learning, the initiating processes that lead towards those ends are of the utmost importance, and we need to consider them as ends in themselves. This includes the activities, the experiences and all the material results that are produced during the processes of making, as distinct from the architectural end result. The built artefact, that closes off the process, is an end for sure but also a kind of alibi, or rather, an incentive that is needed to drive the process, to keep it going, to give it a tangible goal to move towards, and to keep the actors within it motivated and engaged. Seen from this perspective the architectural artefact is something that also articulates and embodies the successes and the failures that were part and parcel of the process of development and construction.

Conversely, apparatus and its assortment of tools and techniques are commonly seen as 'means' to an end. Almost invariably and by definition they refer to, and are incorporated in, the technical practices or activities that initiate and ultimately lead to a thing being made, but not to that very thing itself. In this sense apparatus, tools and techniques are instrumental, i.e. instruments and operations by which an intended result is brought about. They need to serve the end and have to contain capacities that help to achieve it, which is another way of saying that they must be useful, efficient and performative. I reckon that most of us would consider this to be their most relevant asset, namely the potential to be used for what they were meant to, for achieving a strictly defined goal. The statement that *'tools shape materials that make forms, not the other way around'* (Barkow Leibinger 2009, p.1), is a common example of this stance, and by analogy, it can be extended to incorporate or apply to apparatus as well.

Unfortunately though, this way of seeing reduces both the notion of tool and apparatus to use, downstream of their coming into existence, and it tends to limit our role to that of an end-user. For instance, seeing tools as something *'ready-to-hand'* (Heidegger), ready to be deployed as aids for us to perform the many actions of fabrication, presupposes that the tool already exists, not that it still has to be made, and it implicitly fosters dependence on what is made available to us as tools, rather than empowering us to make our own and take on a more active role as tool-makers.

Tools impact on what we do and on what we are capable of doing. Following Richard

Means and Ends

Sennett's account in The Craftsman, *'using new tools and old tools in novel ways'* enables us to *'gain a new understanding of the natural world'* (Sennet 2008, p.195). What he makes manifest is that shaping tools amounts to shaping possibilities, and existing tools embody this explorative development that brought new actions within reach and before invisible things within view. Positioning ourselves inside of these processes of tool-creation holds a promise of going beyond a view of means as something by which something is done, towards a view of means as the manner in which something is done. In other words, it implies a move from the question of 'what' tools to use for a job towards a question of 'how' to devise the adequate set-up, including tools and techniques, for achieving our ends. For that to be possible we have to make a case for their transformative potential and ultimately for making that potential intelligible.

_ During the workshops we have regularly been confronted with situations in which certain necessary tools were lacking, either because we did not provide them, or because the particular made-to-measure that one needed for the job did not exist. This absence of tools and the awareness of a need arising from the situations embedded in the activities of making things can be picked-up and used as an incentive to design and fabricate them.

The primary tools at our disposal are first and foremost our body and hands of course, and it is through and with them that sensorial experience and functional skills join forces. It goes without saying that both hands and body are incredibly versatile tools, but they are constrained by our human physical possibilities, as f.ex. with regard to our capacities to experience and cope with strain and pain, or to the intensity of forces we can take on, or to degrees of precision, fatigue, etc. Depending on the conditions, we can experience that our bodily tools may place important limits on, or even be felt as inadequate for doing what we want or need to do.

But our body is just one of the sites of resistance that makes us realise that we need something more than what we have at hand. The point is that we are not the only agents involved in the processes of making. We are engaged in a relational situation with other agents and the influences between them are reciprocal. It is way too anthropocentric to say that it is our hands and body 'as such' that impose limits on the possibilities, it is rather the combinations or confluence of hands/body with (construction-) material, designed ends, environment, workplace and co-workers to name a few, that together set the limits and create a need for additional means.

When the material changes for example, which happened by default every edition of the

Means and Ends

workshop, and/or by modifying the rules of the game (the rules of engagement), and/or by revising the desired results (the design), and/or by making combinations of those and other parameters, the necessity for tool-use and tool-making changes. Sometimes these changes can be very subtle but at other times they can become substantial.

Very roughly speaking we can distinguish two groups amongst the several workshops that we did. A first one can be termed as fairly low-tech and hands-on, primarily organised on the basis of a direct exchange between hand/body and the material. This applies to the wicker-workshop in Poland (flexibility, pre-tension and a tool for cutting), the brick-workshop in Holland (stacking and geometrical pattern combinatorics) and the stone-workshop in Ireland (stacking, body-power and selection combinatorics). In those three workshops almost no additional (independent) tools were needed, except the logistical tools for having the material delivered to the place of work of course, and the tools needed to run the industrial production processes or the processes for cultivating and harvesting the wicker. But I will leave those out of the picture in order to be able to concentrate on the construction processes within the workshops themselves.

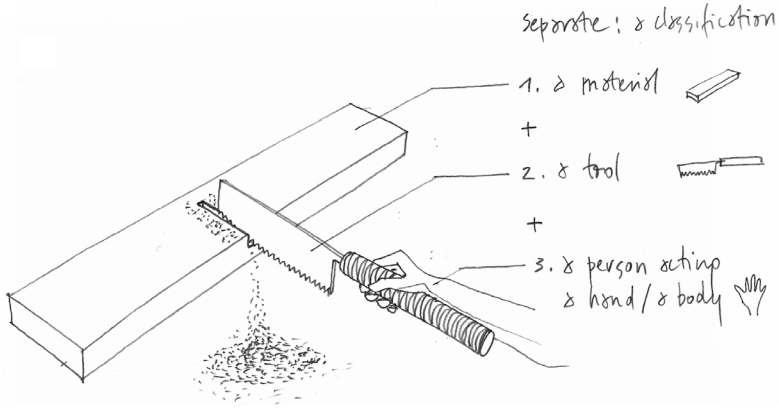
For the other workshops, with concrete in Denmark, with wooden plates in Belgium, massive wood in Liechtenstein and steel re-bars in Spain, the picture is different, to say the least. Working with steel reinforcement bars having a diameter of 6mm and a length of 6m may not seem that challenging when seen from the distance of this page, but actually it was. When one engages steel rods with the hands and the body as principal tools, one experiences directly what a tough material it is to handle properly. Though being flexible and pliable, it is stiff and hard as well, and the physical effort one has to exert, and thus the amount of energy one has to put in, to change its straight pre-given shape into bended curves can be substantial. Bending in a controlled way, with dimensional consistency required the development of tools and a regulated sequence of actions, which became a fascinating creative process in itself.

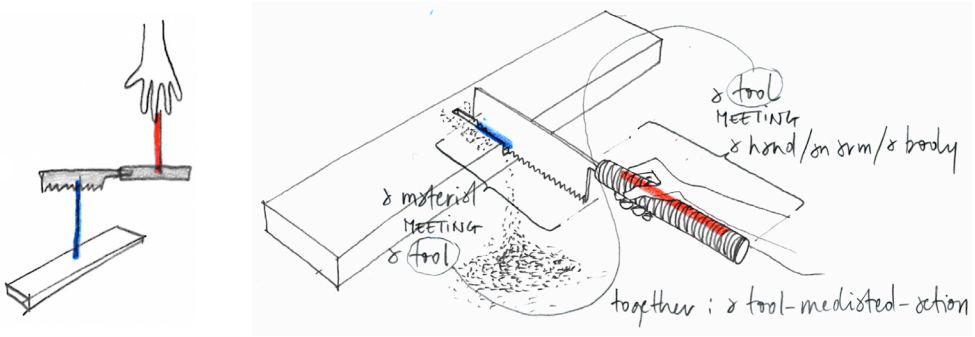
an Extension or an Intermediary

_ The situations encountered during the respective workshops - some due to be developed more in detail hereafter - will prove to challenge the uni-directional manner in which we commonly think of tools as instruments that empower us, or that enable us to exercise or impose our will to form on matter. The maxim stating that *'the tool is an extension and specialisation of the hand that alters the hand's natural powers and capacities'* (Pallasmaa 2009, p.48) duly expresses this attitude. It is the dominant view focussing on the tool as something that is directly determined by and for performing certain specific instrumental actions by us, and as being a specialised and prosthetic device that adds strength, precision, sensitivity, sharpness or whatever other additional functional feature to our hands and body. *'When in use, a tool is a sort of extension of the hand, almost an attachment to it or a part of the user's own body, and thus is no longer a part of the environment of the user. But when not in use, the tool is simply a detached object of the ennvironment,...'* (Gibson 1986, p41).

I reckon that this way of framing the issue is recognisable, and when we apply its logic to an everyday and recurrent activity like cutting a piece of wood, we can at first recognise three *'detached'* entities, i.e. the person acting, the substance or material *'on'* which the action is performed and the object that is taken in the hand and *'with'* which the action is performed, the tool. Each one of them can clearly be distinguished from the others since identifiably different and seemingly autonomous. Within the activity of sawing itself, the tool is then made to be integral to the body of the person, the volitional subject imposing his will on the material. By a sleight of hand we go from three entities to only two, being the material and a kind of hybrid, a tooled human body.

_ Although describing the situation in these terms may appear to make sense, certainly





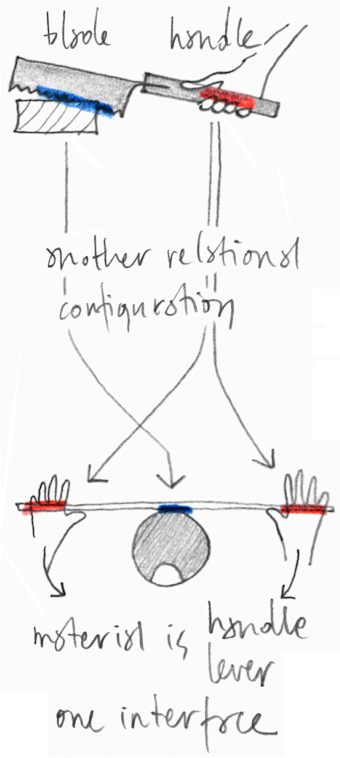
an Extension or an Intermediary

in view of the quotations mentioned above, it is nonetheless wrong, and if not wrong it is seriously defective. At first because it is, again, too anthropocentric, and second because it veils what a tool is supposed to do, namely to mediate between actors engaged in the activity. A tool is actually a *'mediating device'* whose position is *'in-between'*. It is not of the body, nor is it of the material, it is of both. Once integrated in a process of making, a tool becomes part of the *'interface between the object (material or artefact or organism) and an environment which, in the case of the artefact, critically includes its 'maker'* (Ingold 2000/2011, p.345). The saw is in-between the hand/arm and the wood, that is why it is relational. It does not extend the body but rather connects it with the material. The hand holds it, but at a certain moment the wood also holds it and at that moment the action of sawing might bear more resemblance to a tug of war than to a technical operation. During the action of sawing our body is physically connected with the material by means of the tool, and through it the material fabric is made contiguous in such a way that we can feel the substance, it's resistance, it's strength, affecting us, as much as we affect it with our pushes and pulls that steadily make the incision grow. It is only by being incorporated in this reciprocal exchange, mediated by the tool, that the material can inform us and that we can in-form, i.e. shape it or impose a form on it.

_ A tool, and by extension the apparatus of which it can be part, modifies the conditions in which the work is performed by bringing about a qualitative change in the relationships between a material, ourselves as 'makers', the artefact that is under construction, and the place in which the work is being executed. A tool induces a *'transformation in the system of relationships within which the artefact comes into being'* (Ingold 2000/2011, p.345), and our experience, accumulated progressively, workshop after workshop, confirms that this is indeed the case. It also marks a difference between the workshops where the construction activities were primarily unmediated and characterised by direct physical contact between body and material (brick, stone and wicker) and the others in which tool-mediation and tool-technicity were prominent issues (concrete, wood and steel).

It is the combination of both their 'mediating' and 'transformative' potentials that make tools and apparatus utterly interesting as part of a pedagogy of making 'architectural' artefacts on a one on one scale, especially when they become design questions that emerge from within the activities of construction in which one is actively engaged.

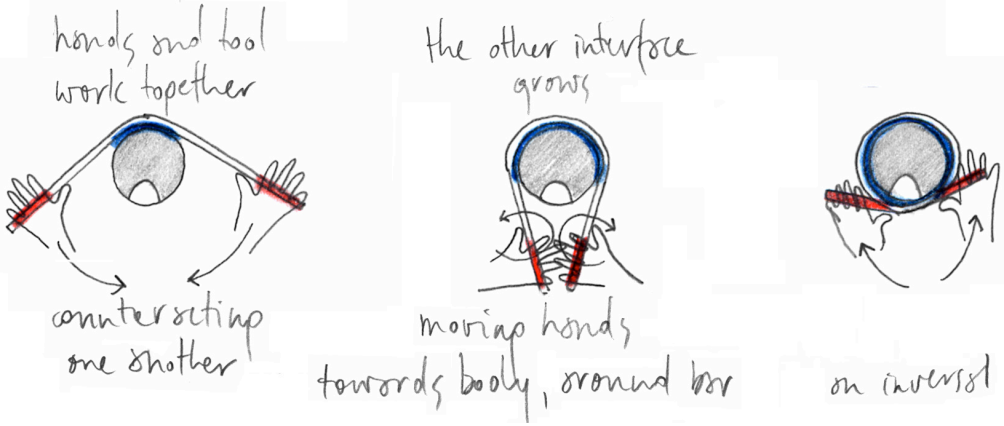
Reciprocal Determinations



_ Tools are '*equipment for action*' and their use is inherently situated '*within some worldly situation*' (Crawford 2009, p.164). As with their use, their coming into existence is as much determined by the concrete circumstances in which the problems they are supposed to tackle or the situations they are expected to mend arise, i.e. within the performance of acts of making. As such, a tool determines the thing that is made with it and conversely its characteristics are themselves determined by that very thing, simply because it is created from the properties it anticipates upon.

In this context, the practice of making tools must by definition be a design practice too, because the underlying orientation is towards modifying an existing situation that is problematic and needs improvement with regard to the quality of the work, it's outcome, it's procedures, it's actions and/or the conditions within which it is performed. It is a design issue because *'the aim of designers is to modify human-environment interactions and to transform them into preferred ones. Their stance is prescriptive and diagnostic. … they not only look at what is going on in the world (descriptive stance), they look for what is going wrong in the world (diagnostic stance) in order, hopefully, to improve the situation'* (Findeli 2010, p.293). In other words, creating tools is projective, i.e. oriented towards a future situation that is different from the existing one.

The tools developed during the workshops have to fit into a work process and become integral to it, meaning that they have to participate in achieving a desired result. The production of approximately fifty matching steel rings, about 450 mm in diameter, gave way to demands with respect to both the shaping of circular form and consistency in the fabrication of a repetitive series. At first the rings were shaped by hand, but achieving the desired correspondence between the rings proved to be extremely difficult, and the



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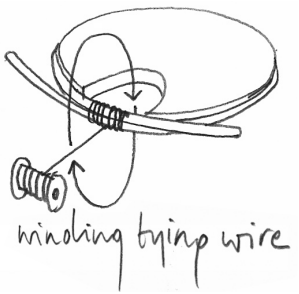
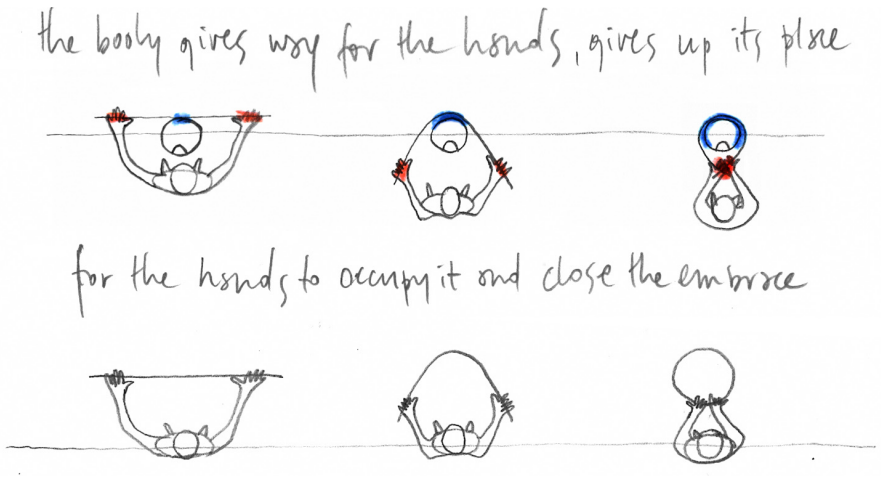


development of a fit-for-purpose jig was indispensible for ensuring the required geometric and dimensional consistency. But in order for this to be possible the tool had to incorporate a whole set of other specifications: assisting the hands and the body with arresting, retaining, bending, giving form, giving dimension and with making a connection between two ends of a steel rod, hence the notch on one side facing the hands, freeing space for tying.

What is more, the tool needs to possess a capacity to assist/participate in the execution of a sequence of manipulations/operations, just as it needs the capacity to withstand and counteract the forces applied simultaneously by body and steel. All these qualities have to be designed and constructed into it, and in this case that would be difficult, not to say impossible, without a feel of what it takes to carry out the job in the tool's absence, accompanied by the intensities of stress and strain experienced while bending the steel freehand and without the repetitive experience of mistakes and failures, whose existence the tool externalises. It is a material expression of difficulties encountered during the process and that needed a certain kind of attention of their own. The difficulties and the way in which they can be solved by means of *'technical processes and procedures, are visibly evident in the form of the tool itself'* (Hale 2014, p.200), they are inscribed in it's fabric and structure. And in this sense they can indeed be seen as a *'means of capturing and passing on our acquired knowledge'* and as a form of *'exteriorisation of memory'* (ibid. p.200)

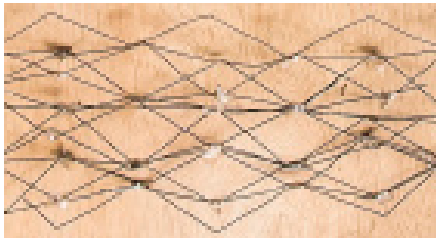
cf. Flusser, Vilém; The Shape of Things, A Philosophy of Design; Reaktion Books Ltd, 1999. pp.18-19: *'The words* design, machine, technology, ars *and* art *are closely related to one another, one term being unthinkable without the others, and they all derive from the same existential view of the world. However, this internal connection has been denied for centuries (at least since the Renaissance). Modern bourgeois culture made a sharp division between the world of the arts and that of technology and machines; hence culture was split into two mutually exclusive branches: one scientific, quantifiable and* hard, *the other aesthetic, evaluative and* soft. *Thisunfortunate split started to become irreversible towards the end of the nineteenth century. In the gap, the word* design *formed a bridge between the two. It could do this since it is an expression of the internal connection between art and technology. Hence ..., design more or less indicates the site where art and technology (along with their respective evaluative and scientific ways of thinking) come together as equals, making a new form of culture possible'.*



Can the implications of those intricacies be truly understood when we simply see the tool as an object out there, without considering the events that surround it? Using a tool is an event and making one is too. Is tool/technique not a tool-mediated action in which a dialectical relation unfolds between material, tool and body rather than an object?

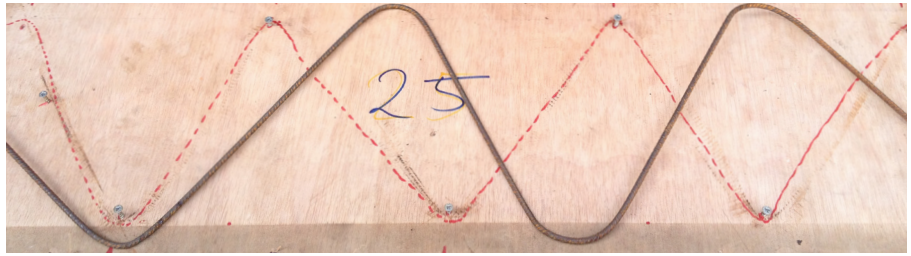
The tool takes a position in-between, in this case even at the centre, with material and body surrounding it. The presence of the tool changes the handling of the steel bar by hands and body in a subtle though significant way. Without it the body can stay put, but when the tool is present in-between, the body has to make place for the hands that are performing a circular movement, surrounding the tool, whilst holding and in-forming the steel bar in coordination with the tool. It is imperative for the whole body to move, whereas in the other untooled case, it is not really necessary for it to do that because the steel bar can move instead. It demonstrates how a tool influences the way in which a body occupies the space around it during the sequence of formative moves. Those movements had to be repeated over and over to make ring after ring, and eventually they became a rhythm of fabrication.

Controlled Approximations



_ Making one part, repeatedly or not, does not amount to the whole work and most of the time parts have to be arranged together to form a comprehensive structure. A construction made with steel lines can clarify why it is necessary to extend the range from the concept of tool as an individual instrument to be taken in the hand, towards the notion of a 'construction of means' or the set-up of a complex of resources, an apparatus.

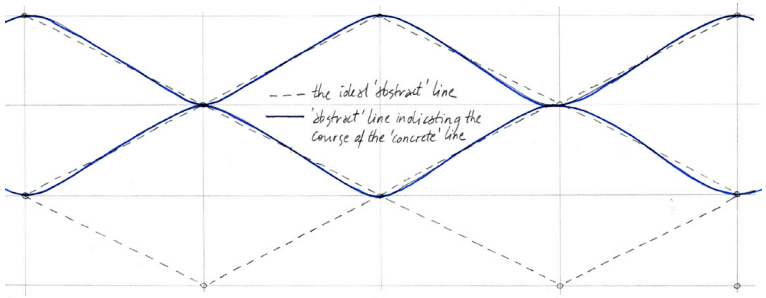
The intention was that the construction/design-process would result in a space frame with a span of 7m, assembled from steel bars having a diameter in section of 6mm and a length of 6m. Although it is normally not part of the workshop-procedure, a preliminary scale model, that depicted the wished-for configuration of lines, was made with wire. The existence of such a mock-up at reduced scale always proves to be a tricky issue, because it almost automatically introduces a tension between two conflicting modes or ways of seeing: the model 'for' versus the model 'of', or in other words, it introduced an interesting tension between means and ends. This tension has been running as a continuous thread through the whole process of making. The 'model of' is a representation, an image to be re-produced and the 'model for' is a relational pattern that specifies an arrangement. *'The first way of seeing emphasises the apparent in a form, the second way emphasises the form in the appearance'* (Flusser 1999, p.26)



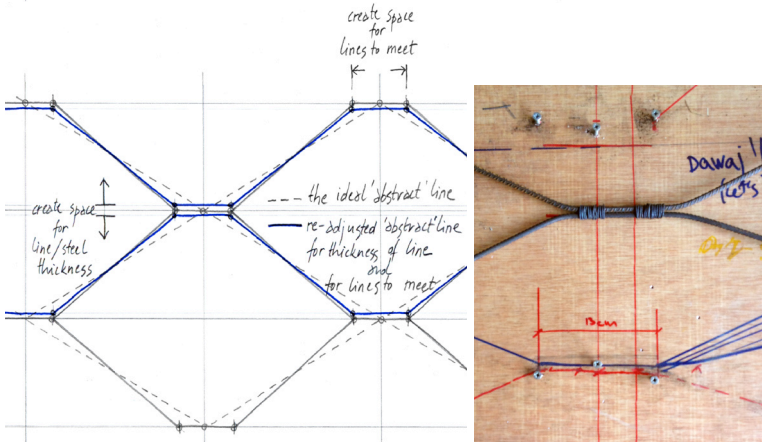
Giving curvature to a straight line is one of the first issues at hand, and sequences of pulling and pushing, bending and straightening, adjusting and readjusting organise the formative moves that have to be performed, on and on, to shape and reshape. It amounts to a series of attempts to make a curved steel line conform to a preset model, a drawn line. Drawing the line is relatively easy and straightforward, even in a freehand mode, but making the steel line conform to the standard, set by the drawn one, is quite another matter

To make it simpler one could drop the demand for conformity and the requirement for increased accuracy that it implies. But since the goal of the activity is to make a space-frame in which lines are assembled with other lines into a fabric of lines, that option is not a plausible one. This knowledge was not pre-given though; it was articulated as a result

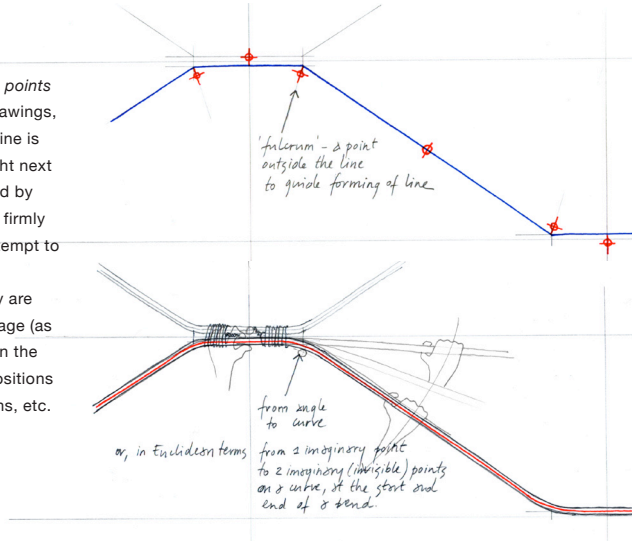
a 1st approximation:
The sharp corners, though drawable, are unmakable with the 6mm thick rebar.
The shape has to be re-adjusted and made less sharp, more soft and round.



a 2nd and 3rd approximation:
Lines meet and have to cohere. Space must be provided to unite the lines, to make them hold together. And space must be provided to accomodate for the dimension of the material where lines converge. Two re-adjustments of the geometry are required, again subjecting the initial 'abstract' model to necessary transformations.



a 4th approximation
'A straight-line is (any) one which lies evenly with points on itself'. Euclid's definition may apply for the drawings, but does it for the steel lines? The (form) of the line is defined by points outside of it's course, lying right next to itself, rather than on it. These points embodied by screws act as jigs that hold and support the line firmly when force is applied to it by the hands in an attempt to modify it from straight to curved.
All corners are curved instead of sharp, and they are all more or less unique due to variations in leverage (as the hand's position always differs), fluctuations in the intensity of the applied force, varying support positions of the jigging screws, opposite bending directions, etc.



Controlled Approximations

of making a first piece, which demonstrated that a much higher degree of control and accuracy was needed for both fabrication and assembly. The necessary combination of lines substantially modifies the setting, since it creates a web of constraints. Every single line that composes the structure is not autonomous but situated within a context of other lines. They are components of a system and as such a relational reciprocity, originating from arranging them together, is ineluctable. The fairly simple assumptions that a line has to meet one or more other lines in certain defined places and the fact that this meeting has to fit, has an impact on how to shape lines, and methods need to be devised that ensure correspondence. It is interesting to see that an increased need for accuracy and control of conformity to a standard, seem to emerge naturally from the context of assembling lines together in an 'orderly arrangement'.

Experience with the first piece, that became a kind of unintended prototype, demonstrated quite convincingly that a thorough revision of the methodology of fabrication was imperative, if a satisfactory result was to be achieved. All kinds of unanticipated problems arose, problems that are pretty much unimaginable when one is not implicated in the practice of construction, or in other words, *'when the conception of work is removed from the scene of its execution'* (Crawford 2009, p.208). The *'unambiguous experience of being wrong'* (ibid, p.204) effectively demonstrated the unpredictability that is part and parcel of making things and the risks of failure that are inherent in it. It also proved that the scale model and the process that led to it were inadequate for anticipating on what can really be made in practice. As a consequence it lost its initial meaning as a model 'of' or as the image that was meant to be validated by its reproduction in a built object. This experience of an ideal shattered by physical reality proved to be frustrating and distressing for most students involved in this project, and a few of them took quite some time to get over it.

The failure induced a momentary interruption in the flow of fabrication, and it set a process of gradual reconfiguration in motion, based upon a stochastic process of inquiry, that revealed why things went wrong, and what could be done about it. There were problems of excessive deformation of the space frame (bending and torsion), defective connections, divergent curvatures of component lines and displaced meetings between them. All these shortcomings appeared at first to be internal to the space frame as a structural system, but they actually were not, or at least not entirely. Seeing the problems as essentially internal to a system isolates that system from the environment in which it comes into being. The reconfiguration of the project, that emerged from the failure, progressively demonstrated

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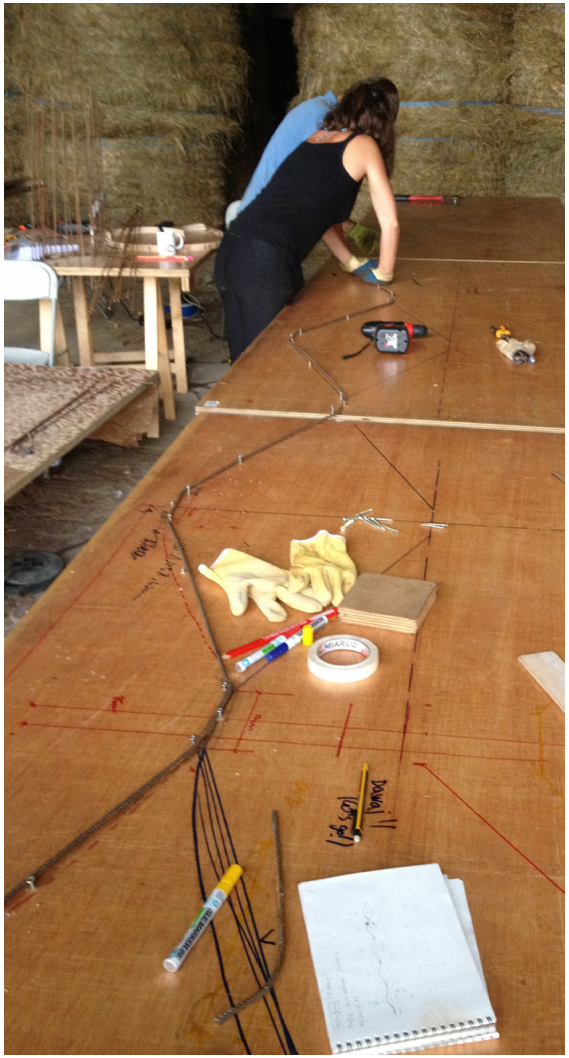

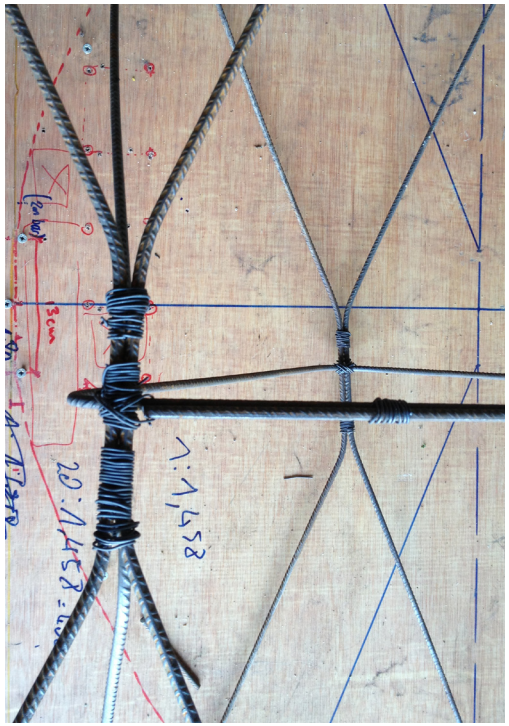

to all involved, that many of its causes were to be found in the relational set-up between persons-acting, means, expectations, goal, contexts of activity and *'activity as dialectically constituted by them'* (Lave 1988, p.20). The defective 'prototype' can be seen as a materialised synthesis incorporating a range of problematic issues that have to be identified and dealt with in due course.

The strategy that was used to cope with the impediments and proceed resulted in something that challenges the classic definition of a tool as an instrument at the scale of the hand. What was produced was an apparatus to fabricate the space-frame at full scale, and it was made tangible in the form of a huge table providing a supporting surface of about 8m by 1,5m, on top of which the components could be shaped and the entire structure assembled. This spatial configuration engendered a qualitative change in the system of relations between the several actors involved. Eventually it became clear that by its existence the end became possible, but also that the end was transformed through the mediation of the apparatus on several levels:

- that of *context* through a re-organisation of the place where the work is done and by a division between the site of fabrication and the building site
- the level of *persons acting together*, i.e. in relation to each other, through re-organising the workspace. The projects have to be realised in collaboration and devising ways to work together and make things together is of primary importance. Making is a social activity with common ends and within shared conditions. The tool-table-apparatus is a means to organise the work together around it, simultaneously or not, sometimes independently and at other times in coordination.
- the level of *procedures*: the table allowed for shaping lines and assembling them simultaneously and in parallel.
- the level of *control of conformity* to a standard: on the table top a template was drawn of one line, soon to be complemented by another next to it that meant to visualise both presence of that other line as well as the meeting with it. The template was modified as compared to the initial template and redrawn according to subsequent approximations that gradually improved the line's shape in accordance to the requirements of the whole.
- the level of *precision*: the addition of fulcrum points allowed for more precise bending; the flat surface allowed for more precision in making the assembly and realising the connections, which in turn made the overall shape more precise.

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- the level of *persons acting*: the surface of work that moved up from ground-level (knees in the grass) to table height, increasing comfort for performing the work.

The thing that was constructed for constructing another thing was specialised though versatile, since it had a capacity to be more than one thing: it was a model (template, reference), a surface (to work upon and at), a jig and a place (the table is defined by it's surface, but also by the space around it, the one that we use to stand, to work from, to look from or observe and the place to interact with others and in this sense it had a profound influence on the work as a social activity). It was a mediating device at an architectural scale and level of complexity.

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_ Conceiving and making the material and operational apparatus needed for constructing architectural artefacts, is usually not associated with the architect's tasks, but rather with the tasks of those in charge of the practical execution of the work on a building site. But doing it nonetheless, proves to be not only pedagogically relevant, but also intrinsically creative and imaginative.

Obviously, constructing architectural artefacts in full scale allows us to develop embodied experience of materials and material processes through direct physical engagement within a construction practice, and this experience grants us a more comprehensive understanding of the implications that our choices, articulated within a design, have on both potentials and constraints of that practice. Already for this reason alone the value of constructing at the scale of 'real life' is beyond measure, because it implies *'the ability to see one's actions 'sedimented' in the solid residues of technical practice'* (Hale 2014, p.201).

But there is more to it than this, and this more comes to the fore by means of the position that the apparatus and its assorted tools and techniques take within the processes and actions of making the built work. That built work comes into existence through a complex set of initiating actions that are situated *'in front of the work'* (Hale based on Ricoeur, Paul; 2014, p.202), where our share, as architects participating in these initiating processes is situated too. Once the work is completed our engagement normally ends and we separate ourselves from the work and from the recursive processes of use. Our position with regard to the apparatus and its tools is substantially different, and this difference makes up the core of its pedagogical value.

Apparatus and tools, their conception and making, can be seen as an intermediary project, a project nested within another, but with similar demands and characteristics as the project they are supposed to help construct. Means and ends have to be reconfigured, meaning that the apparatus/tool which is supposed to be a means, during a certain period will be an end in itself, one that has to be brought into existence first, in order for allowing the larger process, that of making the actual or principal end, to proceed. For this to happen, the apparatus/tool must be brought into use and '*this completes my activity of making them, … gives it social reality. … the maker's activity is situated within a community of use…(that) provides running feedback that can be picked up in the course of … activities'* (Crawford 2009, pp.186-187).

The apparatus is made 'for use', but is also 'being used', there is a circularity that yields information back and forth between the making for use and the using itself, and this enables to evaluate achievements, performance and shortcomings in action or practice and sets the scene for improvement. Our relation with regard to the thing conceived and made has

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changed completely, simply because our position has changed from *'the space in front of the work'*, defined by initiating actions or actions of making, to *'the space behind the work'* (Hale based on Ricoeur, Paul; 2014, p.202), marked by recursive processes or processes of use. The development of an apparatus within the larger process of building an architectural object at scale one on one, gives the opportunity to experience both sides, before and after, both creation (projective) and use (feedback) within one and the same process. The point is well captured by the words of Jonathan Hale commenting on a statement by Karl Marx which *'highights two complementary forms of creative experience, which seem to result from the process of making... : firstly the experience of the maker in taking up and transforming a raw material into an object of use; and secondly the experience of the user in taking up an object consciously shaped for human interaction. ... The symmetry between the process of constructing and both inhabiting and interpreting architecture'* (Hale 2014, p.201).

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